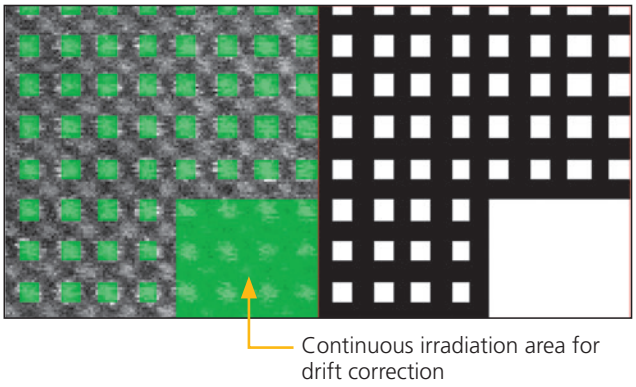
Application note

STEM Damage Reduction using EDM Synchrony

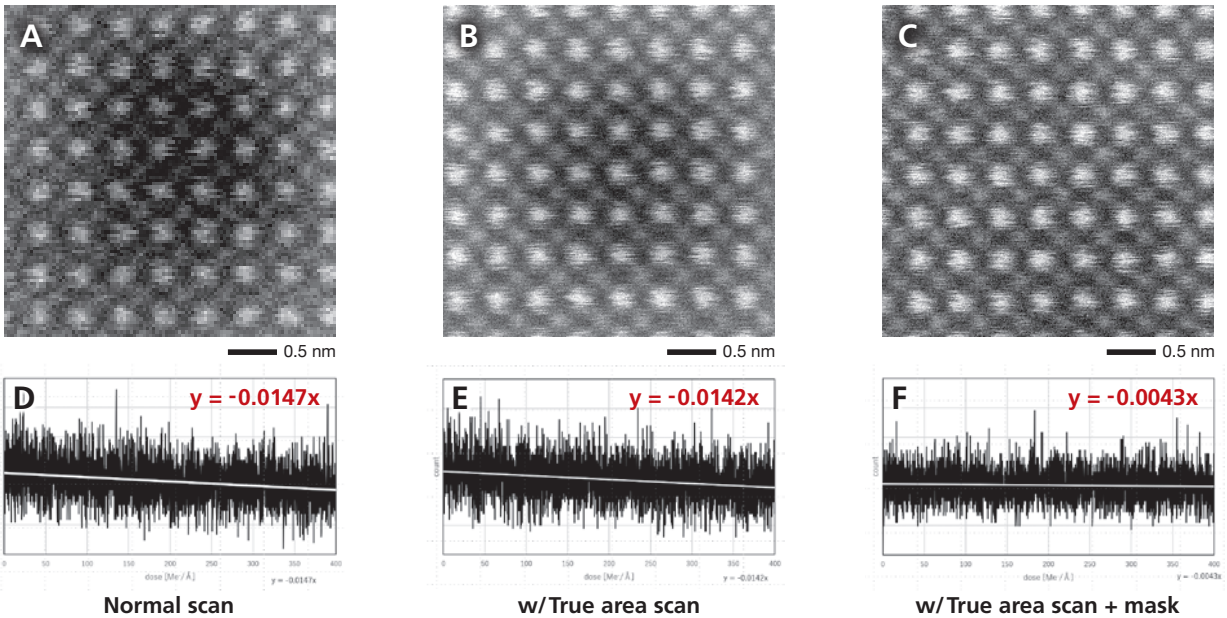
The Dose Painting feature of electrostatic dose modulator (EDM) Synchrony allows the electron dose to be adjusted for each pixel. Here we show an example of how Synchrony can reduce electron beam damage during atomic resolution STEM, by controlling with subatomic precision which regions are irradiated. In an atomic-resolution scan of $SrTiO_3$, we only illuminate the regions near the high-contrast Sr atomic columns, allowing us to track the crystal lattice while avoiding exposure of vacuum areas and other atomic columns. This greatly reduces the damage per scan, allowing quantitative analysis over extended periods of time. Below we show a negligible loss of X-ray intensity even after 10 minutes of continuous scanning. For advanced users comfortable with coding, Synchrony's automation interface lets you customize this approach for your sample, defining any grayscale exposure mask you like based on an atomic resolution preliminary scan. This lets you specifically place dose to reduce damage and enhance the return of the information you care about.



Mask pattern set by Dose Painting

Experimental conditions

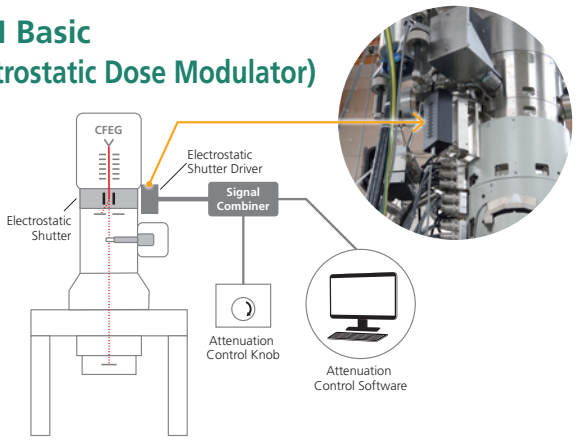
- Sample: Strontium Titanate
- Probe current: 123 pA
- Convergence angle: 11.5 mrad
- Number of pixels: 128 × 128
- Dwell time: 10 µs
- Acquisition time: 10 min
- Dose rate: 110,000 $e^-/Å^2$/scan at 100% duty ratio
- Right image (mask pattern): The black portion is unexposed (duty ratio 0%), while the white portion is fully exposed (duty ratio 100%). Intermediate duty ratios can also be programmed.
- Left image: The mask pattern (green) is superposed on the STEM image (grayscale)
- Instrument: JEM-F200 CFEG/HR pole piece



Normal scan **w/ True area scan** **w/ True area scan + mask**

Images A, B, and C are annular dark field (ADF) images taken after 10 minutes of electron beam irradiation. The irradiation conditions were as follows: A was captured in the standard STEM mode, B in the True Area Scan mode (i.e. with the beam blanked during flyback), and C in the True Area Scan mode combined with a mask using Dose Painting. Graphs D, E, and F show the change in X-ray intensity of strontium with increasing dose over 10 minutes of irradiation. A corresponds to D, B to E, and C to F. Both the ADF images and the attenuation of X-ray intensity demonstrate that the combination of True Area Scan and Dose Painting greatly reduces damage to the sample.

EDM Basic (Electrostatic Dose Modulator)



The Electrostatic Dose Modulator (EDM) is a fast beam blanking system with a pre-sample electrostatic deflector, including electronics and software control. With EDM, the 100,000x improvement in blanking speed immediately improves the clarity of data taken at fast exposure times. EDM can also attenuate electron illumination without affecting imaging conditions, giving TEM and STEM users exceptional control over the dose on their samples.

Programmable STEM with EDM Synchrony

The optional Synchrony upgrade takes EDM's timing and synchronization capabilities to the next level. Synchrony can coordinate with a STEM controller, tracking the probe beam location as it scans across the sample. EDM's lightning-fast electrostatic blanking turns the beam on for a specified time at each pixel, or keeps the beam blanked to completely exclude sensitive regions from dose.

Pulse System

PULSE turboTEM

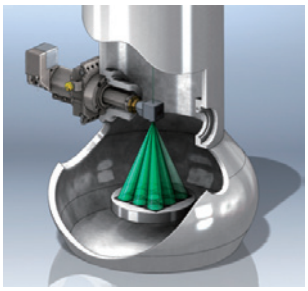
JEOL is pleased to offer Pulse for STEM. Pulse is a real time signal processor that enables digital imaging using standard analog STEM detectors. The device simply plugs in between your STEM detector and data acquisition system to deliver improved signal to noise ratios in your STEM images, particularly in low-dose or high-speed imaging modes.

TEMPO

TEMPO turboTEM

This is a completely new approach to STEM which inverts the typical approach to image formation by using the time required to reach a fixed number of electrons as the basis for pixel intensity rather than the number of electrons detected in a fixed amount of pixel dwell time. Once the desired number of electrons have been counted in a given pixel, the electron beam can then be rapidly blanked resulting in a significant reduction in overall dose applied to a specimen.

Relativity™ Electrostatic Subframing System



The IDES Relativity™ Electrostatic Subframing System multiplies the frame rate of cameras on JEOL TEMs. Microscopes equipped with Relativity™ achieve exceptional time resolution, data throughput, and advanced automation capabilities.

Luminary™ Micro Compact Specimen Photoexcitation System

Luminary™ Micro is a Compact Specimen Photoexcitation System (CPXS) for JEOL TEMs. With Luminary™ Micro, users can study laser-induced phenomena in situ using fast cameras. Combined with IDES/JEOL EDM fast shutter and/or Relativity™ subframing systems, Luminary™ Micro allows users to perform time-resolved studies using pump-probe methods on the microsecond time scale.

EM-IDES-004

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